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Joint Strike Fighter Health Monitoring System

NTIAC develops a real-time health monitoring system for the Joint Strike Fighter funded by the Office of the Naval Research. The ultimate goal is to install the equivalent of a central nervous system in the Joint Strike Fighter, which can instantly report structural health conditions to the crew while in flight. A network of miniaturized acoustic emission sensors, mounted throughout the aircraft, would continually monitor the various components and structures during operation.



American Airlines Airbus A300 Aircraft like the one that crashed in New York after the composite tail separated from the aircraft. NTIAC has developed and field tested an inspection method to detect damage in composite tails prior to breaking. The method does not require disassembly of any components.

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Nondestructive Inspection of Aluminum Compressed Gas Cylinders

Compressed gas cylinders form an integral part of our daily lives. From fire extinguishers to propane tanks, these containers are used throughout our homes and places of work, and as such their integrity is a vital concern. Nowhere is this truer than in the case of compressed air cylinders, including the Self-Contained Underwater Breathing Apparatus (SCUBA) used by divers and the Self-Contained Breathing Apparatus (SCBA) used by firefighters across the country.

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Nondestructive Inspection of Aluminum Compressed Gas Cylinders (continued)

Investigations conducted by both industry and the Department of Transportation (DOT) have indicated that although as a whole, SCUBA and SCBA cylinders are safe, as is the case with any such product some safety issues remain. For example, cylinders made of aluminum alloy 6351-T6 are known to be susceptible to sustained load cracking in the neck and shoulder area of the cylinder. Work into the nature of sustained load cracking has offered new insight into its causes and effects. However, one key factor in preventing damage or failure from this type of flaw has to date been missing, that is, a reliable method of early detection. Although several nondestructive testing (NDT) methods of inspection have been developed, their efficacy has not been established.

In response to this need, the DOT Office of Hazardous Materials Technology, Research and Special Programs Administration (RSPA), contracted the Nondestructive Testing Information Analysis Center (NTIAC) to quantitatively evaluate three common methods of cylinder inspection—

- visual testing (VT),
- eddy current testing (ET), and
- ultrasonic testing (UT).

Conducting an extensive round-robin testing procedure, NTIAC was to evaluate the performance of each technique in terms of its accuracy and reliability in detecting flaws in the neck and shoulder region of the cylinder.

To initiate the project, NTIAC arranged to acquire a test population of compressed air aluminum cylinders that varied in age and condition, and that had been used in the field for some time prior to being "condemned" by an inspector and sent back to the manufacturer. The cylinders were first inspected via the three methods of NDT, after which destructive analysis of select cylinders was used to gauge the results.

Since the ultimate goal of this project was to recommend a testing technique that can be used by inspectors in the field, it was of utmost importance to go beyond the traditional scope of NDT. In many other NDT applications, the testing is conducted by someone with years of experience and training. In this case, however, the NDT method is to be employed by people unfamiliar with NDT as a discipline, such as a part-time high school student working afternoons in a local dive shop.

As such, NTIAC and RSPA both recognized the need to explore the dependence of skill on each inspection technique: an inspector can receive as little as four hours of training before he or she is deemed fit to practice the technique. Results of the project suggest that the skill level of the inspector is a key factor in the performance of the inspection. While there exists a small but appreciable difference in terms of performance between an expert and a skilled inspector, the data indicate that an inspector with only a passing familiarity with the NDT technique fares far worse in terms of his or her inspections.

After analyzing the results of the round-robin nondestructive testing of the cylinders in comparison with destructive analysis, the optimal NDE method was chosen based upon its ability to detect and size flaws. NTIAC's findings in the aluminum gas cylinders project will form the basis of an RSPA recommendation to the compressed gas cylinder community.

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Joint Strike Fighter Health Monitoring System (continued)

During completion of the first phase, NTIAC personnel developed a prototypical “daisy-chained” acoustic emission system and successfully demonstrated it to the U.S. Navy. Data analysis efforts concentrated on correlating properties of the acoustic emission signals to actual physical conditions on the aircraft. These efforts brought to light an issue of communications—the data throughput rate and lost data. Results indicated that a vast improvement would be needed in both speed and reliability when the initial prototype acoustic emission system of 3 or 4 sensors was scaled up to a full system of 10 or more sensors for field application. In response, NTIAC personnel designed and built a communication system based around the Controller Area Network (CAN) protocol. The CAN protocol is an industry standard, having been used since the early 1980’s throughout the automotive industry, photocopiers, and the like. A modern car relies almost solely on CAN to connect every sensor in the vehicle, from magnetic field sensors in the ABS system to the position monitors used to remember a driver’s favored seat and steering wheel position, all connected on a single network.

NTIAC personnel designed a new CAN network protocol, “TRI-CAN,” specifically for a sensor system consisting of distributed nondestructive evaluation (NDE) sensors, such as acoustic emission. TRI-CAN sensors can communicate at speeds of a million bits per second with no loss of data, a 20 times improvement over the initial acoustic emission sensor communication system. The TRI-CAN system is designed with prioritized messages, so that high priority messages are sent and read before lower priority messages; thus a TRI-CAN system operator can be configuring one TRI-CAN sensor while the remaining sensors continue to send data, uninterrupted. In addition, TRI-CAN sensors are designed to accommodate high data rates thanks in part to their nodal nature. A very active TRI-CAN sensor can send its data to a relatively inactive sensor for temporary storage, which can then send the data along to the central computer when acoustic emission activity slows down.

The result is a more robust, faster system but also one that is more generic. While the initial sensor communication system was “tied” to the acoustic emission inspection scenario, TRI-CAN is a generalized protocol suitable for any distributed system of sensors, such as for other NDE applications and condition monitoring systems; or completely different systems, from video cameras to strain gauges, with little to no modification of the network itself.

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